

NORTHEAST OHIO REGIONAL SEWER DISTRICT

2014 Euclid Creek Environmental Monitoring Biological, Water Quality and Habitat Survey Results



**Prepared by
Water Quality and Industrial Surveillance Division**

Introduction

In 2014, the Northeast Ohio Regional Sewer District (NEORS) conducted water chemistry sampling, habitat assessments, and fish and benthic macroinvertebrate community surveys on Euclid Creek. Euclid Creek drains the communities of South Euclid, Lyndhurst, Willoughby Hills, Richmond Heights, Highland Heights, Euclid and Cleveland before emptying into Lake Erie. Sampling was conducted by NEORS Level 3 Qualified Data Collectors certified by Ohio EPA in Fish Community and Benthic Macroinvertebrate Biology, Chemical Water Quality and Stream Habitat Assessments as explained in the NEORS study plan *2014 Euclid Creek Environmental Monitoring* approved by Ohio EPA on April 14, 2014.

The study objective at river mile (RM) 0.55 and RM 1.65, on the main branch of Euclid Creek, was to evaluate the impact of NEORS combined sewer overflow (CSO) discharges and other environmental factors on the downstream water quality, macroinvertebrate and fish communities. This was accomplished by comparing the benthic macroinvertebrate data from the upstream site, at RM 1.65, with data obtained from the downstream site, at RM 0.55. Stream monitoring at these sites also included fish community surveys, habitat assessments and water chemistry sampling. The site at RM 0.55 is required under the Ohio Environmental Protection Agency (Ohio EPA) National Pollutant Discharge Elimination System (NPDES) Permit No. 3PA00002*FD.

An additional objective at RMs 0.55 and 1.65 was to collect baseline data in support of two NEORS capital improvement projects. The Euclid Creek Pump Station project began in late 2014 and the Tunnel Dewatering Pump Station and Euclid Creek Tunnel projects began in December 2010. These construction projects are anticipated to control the number of CSO discharges to Euclid Creek.

RM 1.00, which contains a half-mile long concrete flume installed by the Army Corp of Engineers in 1988, was sampled to monitor the stability and habitat. This concrete flume was initially installed to control flooding in the area; however, it has caused severe aggradation of the stream. Monitoring results will determine if the Army Corps of Engineers should continue with their plan to clean this stretch of Euclid Creek (removal of sediment and vegetation), which could potentially eliminate the limited available habitat that is utilized by fish and macroinvertebrates.

Post-construction monitoring was also conducted at RM 0.40 where restoration work was completed in January 2013. Results from the post-monitoring determined what effect, if any, the restoration had on the chemical, biological and physical characteristics of the creek.

Additional sites within the Euclid Creek watershed were also sampled for the purpose of general watershed monitoring. Sampling was conducted at multiple sites across the watershed to identify issues that might be impacting the aquatic biota.

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Additionally, this study continued to monitor and establish baseline conditions for multi-year sampling stations for trend assessments.

Table 1 lists the sampling sites with respect to RM, latitude/longitude, description, and types of surveys conducted, and Figure 1 is a map of the sampling locations on the creek.

Table 1. 2014 Euclid Creek Sampling Sites

Water Body	Latitude	Longitude	River Mile	Location Information	USGS HUC 8 Number Name	Purpose
Euclid Creek, Main Branch	41.5196	-81.5115	6.90	DS of Mayfield Road	4110003 Ashtabula-Chagrin	Evaluate water chemistry, fish, macroinvertebrates and habitat upstream unnamed tributary
Euclid Creek, Main Branch	41.5612	-81.5315	3.30	US of confluence with the East Branch	4110003 Ashtabula-Chagrin	Evaluate water chemistry, fish, macroinvertebrates and habitat upstream of confluence with East Branch
Euclid Creek, Main Branch	41.5658	-81.5358	2.70	US of Highland Road	4110003 Ashtabula-Chagrin	Evaluate water chemistry, fish, macroinvertebrates and habitat upstream of CSOs
Euclid Creek, Main Branch	41.5738	-81.5470	1.65	Upstream of Saint Clair Avenue	4110003 Ashtabula-Chagrin	Evaluate water chemistry, habitat, fish & macroinvertebrates upstream of NEORSD CSOs
Euclid Creek, Main Branch	41.5828	-81.5552	1.00	Concrete Structure US of Lakeshore Blvd	4110003 Ashtabula-Chagrin	Evaluate water chemistry, fish, macroinvertebrates and habitat in the Concrete Flood Control Structure
Euclid Creek, Main Branch	41.5833	-81.5594	0.55	Downstream of Lake Shore Boulevard	4110003 Ashtabula-Chagrin	Evaluate water chemistry, habitat, fish & macroinvertebrates in support of Ohio EPA Permit No. 3PA00002*FD
Euclid Creek, Main Branch	41.5855	-81.5604	0.40	Upstream of Villa Angela Drive bridge	4110003 Ashtabula-Chagrin	Evaluate water chemistry, fish, macroinvertebrates and habitat post-restoration.
Unnamed Tributary to Euclid Creek, Main Branch	41.532	-81.4970	1.50	US of Richmond Road	4110003 Ashtabula-Chagrin	Evaluate water chemistry, fish, macroinvertebrates and habitat on the unnamed tributary
Euclid Creek, East Branch	41.5743	-81.4948	2.80	DS of Richmond Road	4110003 Ashtabula-Chagrin	Evaluate water chemistry, fish, macroinvertebrates and habitat downstream of airport
Euclid Creek, East Branch	41.5618	-81.5277	0.25	US of Highland Road	4110003 Ashtabula-Chagrin	Evaluate water chemistry, fish, macroinvertebrates and habitat on the East Branch tributary

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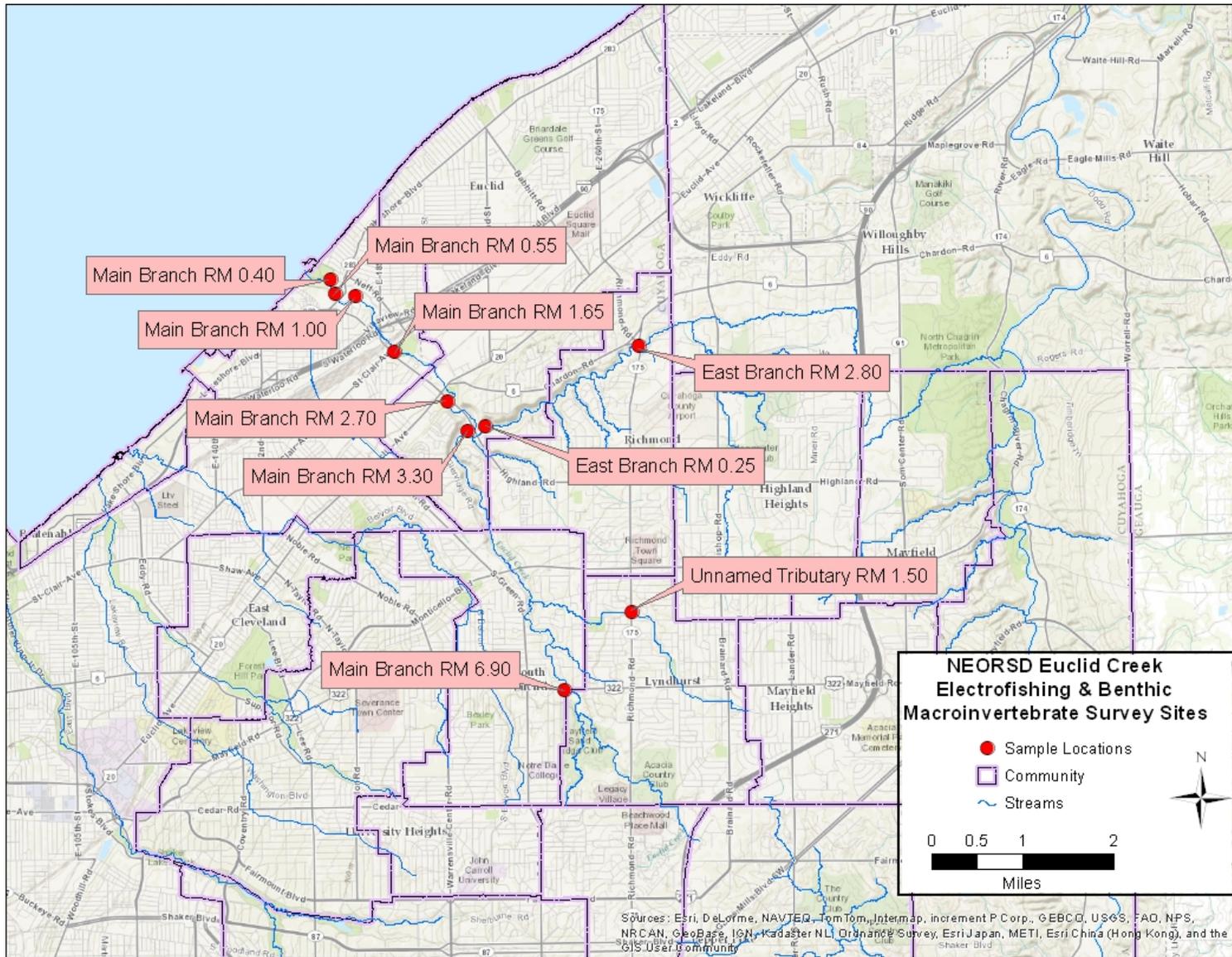


Figure 1. 2014 Sampling Locations on Euclid Creek

Water Chemistry & Bacteriological Sampling

Methods

Water chemistry and bacteriological sampling was conducted five times between June 17 and July 15. The final sampling event on July 22 was only conducted at RM 0.55 to satisfy permit requirements. Techniques used for sampling and analyses followed the Ohio EPA's *Surface Water Field Sampling Manual for water chemistry, bacteria, and flows* (2013a). Chemical water quality samples from each site were collected with a 4-liter disposable polyethylene cubitainer with a disposable polypropylene lid, three 473-mL plastic bottles and a 125-mL plastic bottle. The first 473-mL plastic bottle was field preserved with trace nitric acid, the second was field preserved with trace sulfuric acid and the third bottle received no preservative. The sample collected in the 125-mL plastic bottle (Dissolved Reactive Phosphorus) was filtered using a 0.45- μ m PVDF syringe filter. All water quality samples were collected as grab samples. Bacteriological samples were collected in sterilized plastic bottles preserved with sodium thiosulfate. At the time of sampling, measurements for dissolved oxygen, pH, temperature, and conductivity were collected using either a YSI 600XL sonde or YSI EXO1 sonde. Duplicate samples and field blanks were each collected at randomly selected sites, at a frequency not less than 5% of the total samples collected. Relative percent difference (RPD) was used to determine the degree of discrepancy between the primary and duplicate sample (Formula 1).

Formula 1:

$$\text{RPD} = \frac{|X-Y|}{\left(\frac{(X+Y)}{2} \right)} * 100$$

X= is the concentration of the parameter in the primary sample
Y= is the concentration of the parameter in the duplicate sample

The acceptable percent RPD is based on the ratio of the sample concentration and detection limit (Formula 2) (Ohio EPA, 2013a).

Formula 2: Acceptable % RPD = $[(0.9465X^{-0.344}) * 100] + 5$

X = sample/detection limit ratio

Those RPDs that are higher than acceptable may indicate potential problems with sample collection and, as a result, the data was not used for comparison to the water quality standards.

Results and Discussion

Over the course of the sampling, three field blanks were collected for QA/QC purposes. A total of seven water quality parameters were either rejected, estimated or

downgraded due to potential field blank contamination. It is unclear how the field blanks became contaminated and may be due to inappropriate sample collection, handling, contaminated blank water and/or interference during analysis. Table 2 lists water quality parameters that were rejected, estimated or downgraded from Level 3 to Level 2 data based on Ohio EPA data validation protocol.

Table 2. Potential Field Blank Contamination			
COD	NH ₃	Sb	Zn
Cr	DRP	Total-P	

Three duplicate samples were collected on June 17 at RM 3.30, June 24 at RM 1.50 and July 1 at RM 1.65 for QA/QC purposes. The duplicate sample collected at RM 3.30 revealed two parameters that were rejected due to RPDs that were greater than the acceptable RPD, and the duplicate sample collected at RM 1.65 revealed one parameter that was rejected due to an unacceptable RPD (Table 3). There are numerous reasons for why a large number of parameters were rejected, such as a lack of precision and consistency in sample collection and/or analytical procedures, environmental heterogeneity and/or improper handling of samples. The duplicate sample collected at Unnamed Tributary RM 1.50 did not have any parameters that required qualification of the data.

Table 3. Unacceptable Duplicate RPDs					
Date	River Mile	Parameter	Acceptable RPD (%)	Actual RPD (%)	Qualifier
6/17/2014	3.30	COD	99.7	126.6	Rejected
		NH ₃	33.3	177.4	Rejected
7/1/2014	1.65	COD	45.3	94.5	Rejected

Paired parameters for all samples collected were also evaluated and compared for QA/QC purposes using the same RPD formula as with the duplicate samples. These comparisons revealed three instances in which the subset parameter was greater than the total parameter, but the RPDs still met the acceptable RPD. In these instances, the data was listed as being estimated (Table 4).

Table 4. Unacceptable Paired Parameter RPDs					
River Mile	Date	Paired Parameters	Acceptable RPD (%)	Actual RPD (%)	Qualifier
0.40	7/1/2014	TS/TDS	15.7	0.7	J
2.70	7/8/2014	TS/TDS	17.7	5.2	J
3.30	7/8/2014	TS/TDS	17.0	0.5	J

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All sites on Euclid Creek are designated as Warmwater Habitat (WWH), Agricultural Water Supply, Industrial Water Supply, and Class B Primary Contact Recreation (Ohio EPA, 2009). The results of the water chemistry and bacteriological samples were compared to the applicable water quality standards to determine attainment status for those designated uses. Of that comparison, exceedances were noted for *Escherichia coli* (*E. coli*), copper and zinc.

Mercury analysis for all of the sampling events was completed using EPA Method 245.1. The detection limit for this method is above the criteria for the Human Health Nondrinking and Protection of Wildlife Outside Mixing Zone Averages (OMZA), so it generally cannot be determined if the sites were in attainment of those criteria. Instead, this type of mercury sampling was used as a screening tool to determine whether contamination was present above the detection limit. Based on the sampling that was completed, mercury was not present at levels above those normally found in the watershed (USEPA, 2004).

The Class B Primary Contact Recreation criteria for Euclid Creek includes an *E. coli* criterion not to exceed a single sample maximum (SSM) of 523 colony counts per 100 milliliters in more than ten percent of the samples taken during any thirty-day period, and a seasonal geometric mean (SGM) criterion of 161 colony counts/100mL (Ohio EPA, 2009). The SSM of 523 colony counts/100mL in more than ten percent of the samples taken was exceeded at all of the sites for all 30-day periods. Additionally, all sites exceeded the SGM criterion of 161 colony counts/100mL (Table 5).

Table 5. 2014 Euclid Creek <i>E. coli</i> Densities (most probable number/100mL)										
	RM 6.90	RM 3.30	RM 2.70	RM 1.65	RM 1.00	RM 0.55	RM 0.40	RM 1.50 (Unnamed Tributary)	RM 2.80 (East Branch)	RM 0.25 (East Branch)
6/17/2014	1,539	245	132	351	458	666	744	1310	448	62
6/24/2014*	2,211	2,545	1,682	2,305	2,195	2,675	2,382	6518	1,540	577
7/1/2014*	600	368	351	827	826	953	2,520	2,335	727	174
7/8/2014*	23,740	3,468	2,060	3,423	4,402	4,686	6,592	49,620	8,529	2,242
7/15/2014*	701	216	298	226	360	548	1,564	3,542	515	114
7/22/2014	--	--	--	--	--	275	--	--	--	--
Seasonal Geomean	2,024	703	545	877	1,056	1,030	2,151	5,116	1,171	276
*Wet weather event ¹										
--Sample not taken										
EC=Estimated Count										
	Exceeds simple-sample maximum criterion for 30-day period starting on that date									
	Exceeds seasonal geomean criterion									

¹Wet-weather sampling events: greater than 0.10 inches of rain but less than 0.25 inches, samples collected that day and the following day are considered wet weather samples; greater than 0.25 inches, the samples collected that day and the following two days are considered wet weather samples.

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There are several possible reasons why many of these sites exceeded the SSM and SGM criteria. The NEORSD owns three CSOs on Euclid Creek and there are additional CSOs in the city of Euclid, all of which may cause elevated *E. coli* densities in the creek during wet-weather overflows. Four sampling days were considered wet-weather events, with July 8 exhibiting *E. coli* densities higher than any other day at all of the sites. Nearly a half an inch of rain fell the day before the July 8 sampling with additional rainfall of nearly 0.45 inches while sampling occurred on July 8. Wet-weather events may contribute to elevated bacteria levels by causing discharges from CSOs, storm sewer runoff and urban runoff into Euclid Creek.

Additionally, there are numerous documented improper connections and bacteriological contaminated storm sewers in the cities of Cleveland and Euclid, which could have an impact on the *E. coli* densities seen during dry weather. The issue of storm sewer bacteriological contamination within the Euclid Creek watershed has been thoroughly investigated since 2012 and communicated to the appropriate community for eventual remediation. In 2013 and 2014, NEORSD revisited many of the documented issues and have found that the majority were still active problems. Finally, bacteriological contamination from failing septic systems in the Euclid Creek watershed may also be impacting the water quality at the sample sites.

On July 8, copper and zinc exceeded the Aquatic Life Outside Mixing Zone Maximum (OMZM) and the Tier I OMZM at RM 6.90. RM 6.90 is located immediately downstream of Mayfield Country Club with the upper reaches of the creek running directly through the golf course. As previously mentioned, July 8 was considered a significant wet-weather event, which may have caused substantial runoff from the golf course. This runoff may have potentially introduced pollutants and/or chemicals used on the course for turf management into the creek.

In 2013, the Ohio EPA released a draft Trophic Index Criterion (TIC) designed to determine the degree of nutrient enrichment in a stream. The TIC assigns designations for quality of surface waters based on many factors including nutrients, periphyton, dissolved oxygen, and biological assemblages. This criterion was published in 2011 as a draft, and in March 2013, some aspects of the paper were published in a document called, "Trophic Index Criterion- Rationale and Scoring" (Ohio EPA, 2013b). NEORSD does not assess periphyton; however, nutrients were assessed.

Table 6 shows the nutrient concentrations for the Euclid Creek sites in 2014. All sites, except RM 1.50 (unnamed tributary), scored in the "acceptable" category and are indicative of a stream with minimal nutrient enrichment. RM 1.50 scored in the "threatened" category, meaning the concentrations of nutrients seen at this site are typically observed with high-intensity land use. RM 1.50 is located in a highly residential area with a narrow riparian width; therefore, stormwater runoff from residential lawns containing fertilizer treatment may be the cause of the increased nutrient load at the site. However, considering the remainder of the sites had typical nutrient

concentrations, it would be expected that nutrients would not be having a negative effect on the biological communities of Euclid Creek.

Table 6. 2014 Euclid Creek Nutrient Trophic Index Scores		
River Mile	Average Total Phosphorus (mg/L)	Average Dissolved Inorganic Nitrogen (mg/L)
6.90	0.061	0.441
3.30	0.031	0.392
2.70	0.049	0.346
1.65	0.047	0.376
1.00	0.047	0.626
0.55	0.040	0.500
0.40	0.046	0.405
1.50 (Unnamed Tributary)	0.152	0.317
2.80 (East Branch)	0.123	0.421
0.25 (East Branch)	0.071	0.478

Habitat Assessment

Methods

Instream habitat assessments were conducted once at each site on Euclid Creek in 2014 using the Qualitative Habitat Evaluation Index (QHEI). The QHEI was developed by the Ohio EPA to assess aquatic habitat conditions that may influence the presence or absence of fish species by evaluating the physical attributes of a stream. The index is based on six metrics: stream substrate, instream cover, channel morphology, riparian zone and bank condition, pool and riffle quality, and stream gradient. The QHEI has a maximum score of 100, and a score of 60 or more in streams >20 square miles or a score of 55 or more in streams <20 square miles, suggests that sufficient habitat exists to support a fish community that meets the warmwater habitat criterion (Ohio EPA, 2003). A more detailed description of the QHEI can be found in Ohio EPA's *Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI)* (2006). QHEI field sheets for each site are available upon request from the NEORSW WQIS Division.

A lacustrine QHEI (L-QHEI) was conducted at RM 0.40. The L-QHEI is similar to the QHEI in that it assesses aquatic habitat conditions; however, the L-QHEI is specific to lacustrine zones. Lacustrine is defined as a transition zone in a river that flows into a freshwater lake and is the portion of the river affected by the water level of the lake (Ohio EPA, 1997). Additionally, the L-QHEI is based on only five metrics:

stream substrate, cover types, shoreline morphology, riparian zone and bank erosion, and aquatic vegetation quality. A more detailed description of the L-QHEI can be found in Ohio EPA’s draft *Methods of Assessing Habitat in Lake Erie Shoreline Waters Using the Qualitative Habitat Evaluation Index (QHEI) Approach (Version 2.1)*(2010). According to Ohio EPA (2008), an L-QHEI score greater than 55 is considered an acceptable target.

Results and Discussion

QHEI scores on Euclid Creek ranged from *Fair* to *Good* in 2014. Eight of the 10 sites met Ohio EPA’s target score (Table 7), meaning that these sites have habitat suitable to support a community of warmwater habitat fish species.

Table 7. 2014 Euclid Creek QHEI Results				
River Mile	Type	Date	QHEI Score	Narrative
6.90	Headwater	9/25/14	67.00*	<i>Good</i>
3.30	Headwater	9/15/14	64.50*	<i>Good</i>
2.70	Wading	8/28/14	63.00*	<i>Good</i>
1.65	Wading	8/28/14	74.00*	<i>Good</i>
1.00	Wading	8/28/14	64.50*	<i>Good</i>
0.55	Wading	9/5/14	59.75	<i>Good</i>
0.40	Lacustrary	9/15/14	47.00**	<i>Fair</i>
1.50 (Unnamed Tributary)	Headwater	9/25/14	59.50*	<i>Good</i>
2.80 (East Branch)	Headwater	9/15/14	69.25*	<i>Good</i>
0.25 (East Branch)	Headwater	9/15/14	57.50*	<i>Good</i>
* Site met Ohio EPA target score of 60 (>20 square miles) or 55 (<20 square miles)				
**LQHEI				

Euclid Creek RM 1.65 had the highest QHEI score in 2014, receiving *Good* narrative rating. There were pools greater than one meter, deep riffles and runs with moderate stability. Boulder and sand were the predominant substrate types with stable riffles and runs. There was a sparse amount of instream cover including pools >70cm, rootwads, boulders and woody debris. The QHEI score at this site decreased by 4.5 from 2013, which may be attributed to a lesser amount of instream cover and less diverse instream cover in 2014.

RM 0.25 on the East Branch received the lowest QHEI score in 2014; however, the site still met the Ohio EPA’s target score of 55 for streams <20 square miles. RM 0.25 was comprised of predominately gravel and bedrock substrate with sparse instream cover. This site exhibited poor development and little to no sinuosity. This site received a similar narrative rating in 2013.

According to Environmental Supervisor William Zawiski of the Ohio EPA Division of Surface Water, it is believed that RM 0.40 is most likely within a lacustrary zone that ends near RM 0.55, which means that it may be influenced by lake levels (Personal communication, October 27, 2010). An L-QHEI score of 47.00 (*Fair*) was calculated at RM 0.40; therefore, this site did not meet the L-QHEI target, indicating possible degraded habitat. RM 0.40 was predominantly composed of cobble and sand with sparse to moderate instream cover and a low abundance of aquatic vegetation. The limited aquatic vegetation may be due to scouring of the immature vegetation from flooding during storm events in 2013 that caused erosion (Posius, 2013). In October 2013 and May 2014, new vegetation was planted, which may help increase the L-QHEI score in future years; therefore continued monitoring at this site is imperative.

Electrofishing

Methods

Two quantitative electrofishing passes were conducted at each wading and lacustrary site and one quantitative electrofishing pass was conducted at each headwater site in 2014. A list of the dates when the surveys were completed, along with flow as measured at the United States Geological Survey gage station 04208700 in Cleveland, is given in Table 8. All of the sampling sites, except RM 0.40, are considered either headwater (gradient <20 square miles) or wading (gradient >20 square miles). Sampling was conducted using longline and backpack electrofishing techniques and consisted of shocking all habitat types within a sampling zone while moving from downstream to upstream. The sampling zone was 0.15 kilometers for the headwater sites and 0.20 kilometers for the wading sites. Euclid Creek RM 0.40 was sampled using boat electrofishing techniques and consisted of shocking all habitat types within a sampling zone (0.5 kilometers) while moving from upstream to downstream. The methods that were used followed Ohio EPA protocol methods as detailed in *Biological Criteria for the Protection of Aquatic Life, Volumes II* (1987a) and *III* (1987b). Fish collected during the surveys were identified, weighed (for wading and lacustrary sites only) and examined for the presence of anomalies, including DELTs (deformities, eroded fins, lesions, and tumors). All fish were then released to the waters from which they were collected, except for vouchers and those that could not be easily identified in the field.

Table 8. 2014 Euclid Creek Electrofishing Surveys		
Site	Date	Stream Flow (ft ³ /s) [#]
6.90	6/23/2014	24
3.30	7/15/2014	9
2.70	7/1/2014	12
	8/28/2014	14
1.65	7/1/2014	12

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Table 8. 2014 Euclid Creek Electrofishing Surveys		
Site	Date	Stream Flow (ft ³ /s) [#]
	8/28/2014	14
1.00	7/1/2014	12
	8/28/2014	14
0.55	6/20/2014	19
	8/25/2014	17
0.40	7/10/2014	19
	9/24/2014	27
1.50	6/23/2014	24
2.80	6/30/2014	26
0.25	6/30/2014	26

[#] Provisional flow data obtained from USGS 04208700 Euclid Creek flow gauge in Cleveland, Ohio

The electrofishing results for each pass were compiled and utilized to evaluate fish community health through the application of two Ohio EPA indices, the Index of Biotic Integrity (IBI) and the Modified Index of Well-Being (MIwb). The IBI incorporates 12 community metrics representing structural and functional attributes. The structural attributes are based upon fish community aspects such as fish numbers and diversity. Functional attributes are based upon fish community aspects such as feeding strategies, environmental tolerances, and disease symptoms. These metrics are individually scored by comparing the data collected at the survey site with values expected at reference sites located in a similar geographical region. The maximum possible IBI score is 60 and the minimum possible score is 12. The summation of the 12 individual metrics scores provides a single-value IBI score, which corresponds to a narrative rating of *Exceptional*, *Good*, *Marginally Good*, *Fair*, *Poor* or *Very Poor*. RM 0.40 was evaluated using the lacustrine IBI (LIBI), due to its location near the mouth of the river. The 12 metrics utilized for headwater, wading and lacustrine sites are listed in Table 9.

Table 9. IBI Metrics		
Headwater	Wading	Lacustrine
Total Number of Native Species	Total Number of Native Species	Total Number of Native Species
Number of Darters & Sculpins	Number of Darter species	Number of Benthic Species
Number of Headwater Species	Number of Sunfish Species	Number of Sunfish Species
Number of Minnow Species	Number of Sucker Species	Number of Cyprinid Species
Number of Sensitive Species	Number of Intolerant Species	Percent of Phytophilic Individuals
Percent Tolerant Species	Percent Tolerant Species	Percent of Top Carnivores
Percent Pioneering Species	Percent Omnivores	Number of Intolerant Species
Percent Omnivores	Percent Insectivores	Percent of Omnivores

Table 9. IBI Metrics		
Headwater	Wading	Lacustrary
Percent Insectivores	Percent Top Carnivores	Percent of Non-indigenous Individuals
Number of Simple Lithophils	Percent Simple Lithophils	Percent of Tolerant Individuals
Percent DELT Anomalies	Percent DELT Anomalies	Percent with DELT Anomalies
Number of Fish	Number of Fish	Number of Fish

The second fish index utilized by Ohio EPA is the Modified Index of Well-being (MIwb). The MIwb, Formula 3 below, incorporates four fish community measures: numbers of individuals, biomass, and the Shannon Diversity Index (H) (Formula 4 below) based on numbers and weight of fish. The MIwb is a result of a mathematical calculation based upon the formula.

Formula 3:
$$MIwb = 0.5 \ln N + 0.5 \ln B + \bar{H}(No.) + \bar{H}(Wt.)$$

N = Relative numbers of all species excluding species designated as highly tolerant, hybrids, or exotics

B = Relative weights of all species excluding species designated as highly tolerant, hybrids, or exotics

$\bar{H}(No.)$ = Shannon Diversity Index based on numbers

$\bar{H}(Wt.)$ = Shannon Diversity Index based on weight

Formula 4:
$$\bar{H} = - \sum \left[\left(\frac{n_i}{N} \right) \log_e \left(\frac{n_i}{N} \right) \right]$$

n_i = Relative numbers or weight of species

N = Total number or weight of the sample

An MIwb score ≥ 7.9 (*Good*) is in attainment of the WWH biocriterion for wading sites in the EOLP ecoregion. An MIwb score of 7.4 (*Marginally Good*) is also in attainment, as it is considered non-significant departure (≤ 0.5 MIwb units) from the criterion. An MIwb score of ≥ 8.6 (*Marginally Good*) is in attainment of the lacustrary biocriterion for boat sites in the EOLP ecoregion.

Results and Discussion

In 2014, all of the sites were in non-attainment of the WWH biocriteria and RM 0.40 was in non-attainment of the LIBI and MIwb criteria (Table 10). However, Euclid Creek RM 0.55 was in non-significant departure of the WWH IBI biocriterion for both passes and RM 0.40 was in non-significant departure of the WWH MIwb biocriterion for the first pass.

RM 0.55 was in non-significant departure for the IBI biocriterion, receiving an average score of 36 (*Marginally Good*). Collections from both passes consisted of two

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species of fish that were moderately intolerant to pollution: sand shiner (*Notropis stramineus*) and smallmouth bass (*Micropterus dolomieu*). Nearly 10% of the catch from the August 25 pass consisted of these two species. A commonality between the two passes was the high number of native species and low proportion of DELT anomalies, which may have contributed to the score increasing by 4 from 2013.

The criterion for the LIBI is ≥ 42 (*Good*) and RM 0.40 received an average LIBI score of 24 (*Poor*) and an MIwb score of 7.1 (*Fair*). The highest scoring metrics at RM 0.40 were Number of Native Species, Number of Cyprinid Species and Number of Phytophilic Individuals. Thirty percent of the catch was comprised of phytophilic fish (fish that spawn on vegetation) which included largemouth bass (*Micropterus salmoides*) and pumpkinseed sunfish (*Lepomis gibbosus*). During NEORSD’s 2010 pre-restoration monitoring, RM 0.20 (located within the restoration zone) obtained an average LIBI score of 36 (*Fair*) and MIwb score of 8.1, both failing to meet the biocriteria. Continued biological monitoring at this site is important in order to evaluate the effectiveness of the habitat improvements made.

Table 10. 2014 Euclid Creek IBI & MIwb Results			
Site	Type	Pass	
		IBI	MIwb
RM 6.90	Headwater	20	
RM 3.30	Headwater	32	
RM 2.70	Wading	24	4.9
		26	5.7
RM 1.65	Wading	22	4.4
		26	5.3
RM 1.00	Wading	26	5.1
		26	6.8
RM 0.55	Wading	36	6.9
		36	7.0
RM 0.40	Lacustrary	28*	7.4
		20*	6.8
RM 1.50 (Unnamed Tributary)	Headwater	20	
RM 2.80 (East Branch)	Headwater	22	
RM 0.25 (East Branch)	Headwater	32	
IBI wading criteria ≥ 38 ; MIwb ≥ 7.9 IBI headwater criteria ≥ 40 <i>Italics = non-significant departure from WWH criterion</i> *LIBI criteria ≥ 42 ; MIwb ≥ 8.6			

The lowest IBI score for a wading site was at RM 1.65, which received an average IBI score of 24. The IBI metrics that received the highest scores (5) were for the Proportion of Omnivores, Proportion of Simple Lithophils and Proportion with DELT anomalies. The majority of the remainder of the metrics received a score of one with nearly all of the fish collected being highly tolerant to pollution. The low score at this site may be due to the East 185th Street dam located at RM 1.50, which acts as a migration barrier preventing upstream fish passage. Therefore, attainment of the fish biocriterion at this site may never be achievable unless the dam is removed.

The lowest IBI scores for a headwater site were at RMs 6.90 on the main branch and 1.50 on the unnamed tributary, which both resulted in an IBI score of 20. At RM 6.90, only two species of fish were collected and all of the fish collected were tolerant species. The electrofishing pass at RM 1.50 consisted of only one species of fish, creek chub (*Semotilus atromaculatus*), which is highly pollution tolerant. Both RMs 6.90 and 1.50 had the lowest drainage areas of 3.90 and 1.20 square miles, respectively, and are in highly residential areas. Fish diversity tends to decrease with river size, which may explain the reduced species diversity and failure to meet the IBI biocriterion in these smaller streams (McCabe, 2010).

In 2008, Ohio EPA monitored for fish just downstream of RM 0.25 at RM 0.20 on the east branch. The purpose of the sampling was to collect baseline data prior to the start of a stream restoration project in this segment of stream. The restoration project consisted of removing a dam at RM 0.15 and installing cascading pools immediately upstream of the dam to improve the biological community and water quality. In 2008, an IBI score of 28 was obtained by Ohio EPA at RM 0.20 (within the restoration zone), which was non-attainment of the WWH IBI biocriterion. Ohio EPA also conducted a post-monitoring fish assessment at RM 0.20 in 2011. During this assessment, the IBI score increased to 34; however, the fish community still failed to meet the biocriterion. In 2013 and 2014, NEORS monitoring of RM 0.25 (which is within the restoration zone and slightly upstream of Ohio EPA's RM 0.20 site) acquired IBI scores of 28 and 32, respectively. As part of the restoration, rock cross vanes were installed to help control stream bed grade, keep the stream from meandering, protect the Highland bridge from scour and center the flow through the bridge opening. However, these rock cross vanes may be inhibiting establishment of a WWH fish population due to the height of the rock, which may be preventing the fish from migrating upstream. Although the IBI score increased since 2013, monitoring at this site should continue to determine if the fish community may continue to improve.

The remainder of the sites received narrative ratings of either *Poor* or *Fair*. At RMs 2.70, 3.30 and 2.80, 73%, 57% and 75% of the catches, respectively, consisted of highly tolerant fish species. RM 1.00 also had a high proportion of tolerant species and a low proportion of top carnivores, contributing to this site's non-attainment of the fish biocriteria. Additionally, in 1988, an approximately half-mile concrete flume was

installed by the Army Corps of Engineers to help control flooding in the area. This concrete flume may be inhibiting a healthy fish population from establishing the site. It appears that the number of fish species collected at each site declines upstream of RM 1.00. The average number of fish species collected at RMs 1.00, 0.55 and 0.40 was 18 species; the average number of fish species collected at RM 1.65 and upstream was 5 species. This may be due to the East 185th Street dam that is preventing upstream fish passage. Other contributing factors such as CSO discharges, improper connections, and urban runoff may be negatively impacting the fish community at these sites as well.

RMs 2.70, 1.65 and 0.55 have been evaluated for fish since as early as 2007 in order to determine the impact that NEORSD-owned CSOs may have on downstream biological communities. In 2014, RM 0.55 scored higher than the two upstream sites; however, again, this is most likely due to the East 185th Street dam that is impeding fish movement upstream. Historical IBI data on Euclid Creek at RMs 2.70 and 1.65 show consistent scoring, again possibly attributable to the dam that may be preventing a diverse and healthy fish community at these sites (Table 11). RM 0.55 has shown an overall increase in scoring, with 2014 being the highest ever IBI score for the site since NEORSD began conducting sampling.

Year	RM 2.70		RM 1.65		RM 0.55	
	IBI	MIwb	IBI	MIwb	IBI	MIwb
2007	25	5.1	25	5.2	27	7.4
2008	26	6.6	23	6.2	28	7.4
2009	26	6.9	24	6.2	28	6.9
2010	25	5.7	25	5.5	26	6.6
2011	--	--	25	4.9	26	6.8
2012	--	--	27	6.2	31	7.6
2013	26	6.1	28	5.6	32	7.3
2014	25	5.3	24	4.9	36	7.0

--Fishing survey not completed

Bold indicates nonsignificant departure of WWH biocriterion

Macroinvertebrate Sampling

Methods

Macroinvertebrates were sampled quantitatively using modified Hester-Dendy (HD) samplers in conjunction with a qualitative assessment of Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly), also referred to as EPT taxa, inhabiting available habitats at the time of HD retrieval. Sampling was conducted at both of the locations listed in Table 1. Methods for sampling followed the Ohio EPA's Biological

Criteria for the Protection of Aquatic Life, Volume III (1987b). The recommended period for HDs to be installed is six weeks.

The macroinvertebrate samples were sent to Third Rock Consulting of Lexington, Kentucky, for identification and enumeration. Specimens were identified to the lowest practical taxonomic level as defined by the Ohio EPA (1987b). Lists of the species collected during the quantitative and qualitative sampling at each site are available upon request from the WQIS Division.

The overall aquatic macroinvertebrate community in the stream was evaluated using Ohio EPA’s Invertebrate Community Index (ICI) (OEPA 1987a) and the lacustuary ICI (LICI) for RM 0.40. The ICI and LICI consist of ten community metrics (Table 12), each with four scoring categories. Metrics 1-9 are based on the quantitative sample, while Metric 10 is based on the qualitative EPT taxa. The total of the individual metric scores result in the overall score. This scoring evaluates the community against Ohio EPA’s reference sites for each specific eco-region.

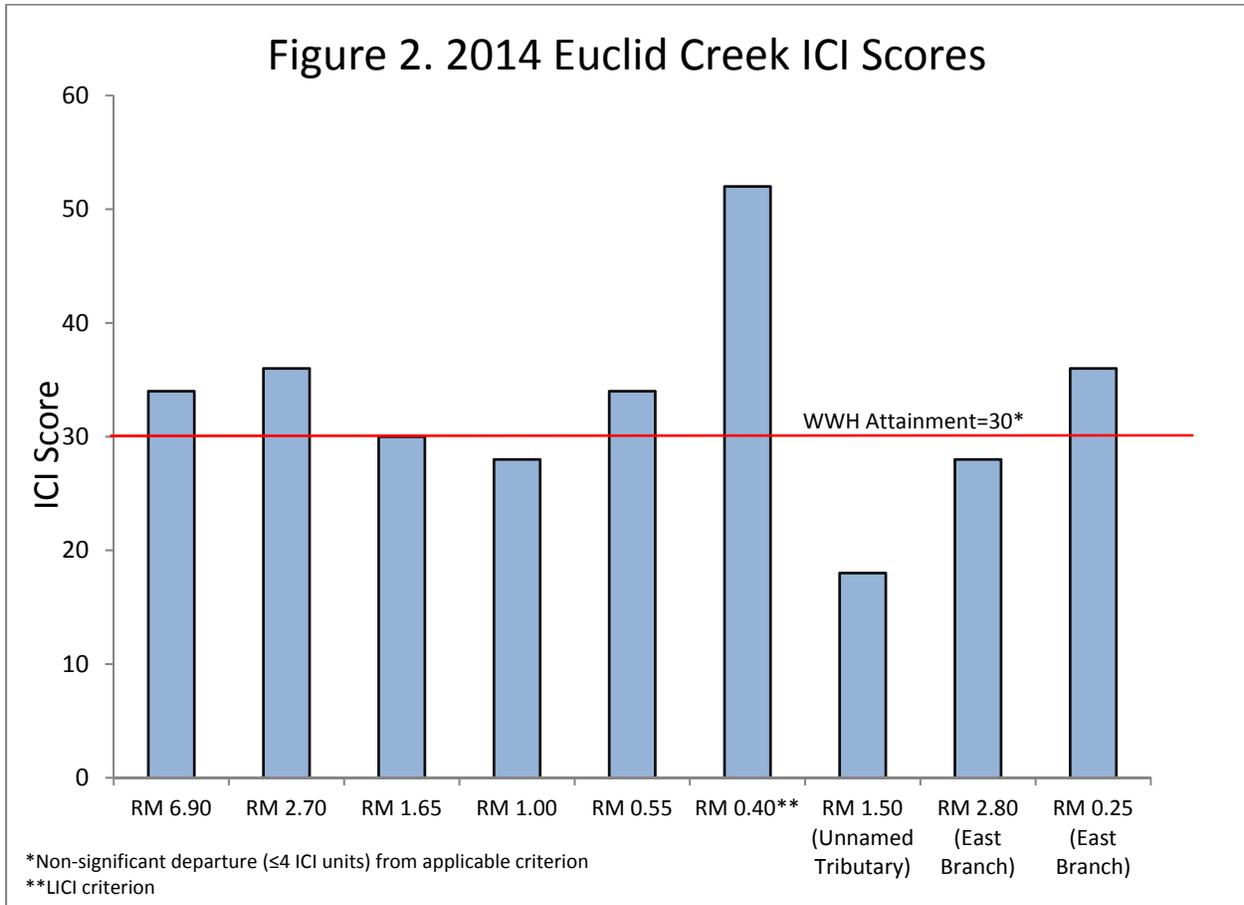
Table 12. ICI Metrics	
ICI	LICI
Total number of taxa	Total number of taxa
Number of mayfly taxa	Number of diptera taxa
Number of caddisfly taxa	Number of sensitive taxa
Number of dipteran taxa	Percent predominant taxon
Percent mayflies	Percent other diptera and non-insects
Percent caddisflies	Percent mayflies and caddisflies
Percent Tanytarsini midges	Percent sensitive taxa
Percent other diptera and non-insects	Percent collector-gather taxa
Percent tolerant organisms (as defined)	Dipteran abundance
Number of qualitative EPT taxa	Number of qualitative EPT taxa

Results and Discussion

In 2014, HDs were installed at all ten Euclid Creek sites and all were retrieved, except for the HD at RM 3.30. It is believed that the HD at RM 3.30 may have been washed downstream or inadvertently removed from the stream, and therefore, only a qualitative assessment was conducted. In this instance, best professional judgment in conjunction with an overall assessment of the site was used to determine the narrative rating.

Of the retrieved HDs, RMs 0.25 (east branch), 0.55, 1.65, 2.70, and 6.90 were in attainment of the WWH ICI biocriterion; however, RMs 1.00, 1.50 (unnamed tributary)

and 2.80 (east branch) were not (Figure 2). RM 0.40 met the LICI biocriterion of 42 and met the intermediate criterion of 34.



RMs 2.70 and 0.25 (east branch) obtained the highest ICI scores (34) in 2014 with narrative ratings of *Good* (Table 14). At RM 2.70, the highest scoring metrics were Number of Caddisfly Taxa, Percent Caddisflies and Percent Tolerant Organisms. Additionally, two taxa collected were considered moderately intolerant of pollution. RM 2.70 has been sampled for macroinvertebrates eight times since 2002 (Table 14). Of the eight sampling events, seven events were in attainment of the WWH ICI biocriterion. This site received an ICI score of 42 in 2013. The reason the score decreased in 2014 may be due to the HD being mostly buried, with one block out of the water during retrieval. Although buried, the HD was still able to house a relatively healthy macroinvertebrate community, leading to attainment of the ICI biocriterion.

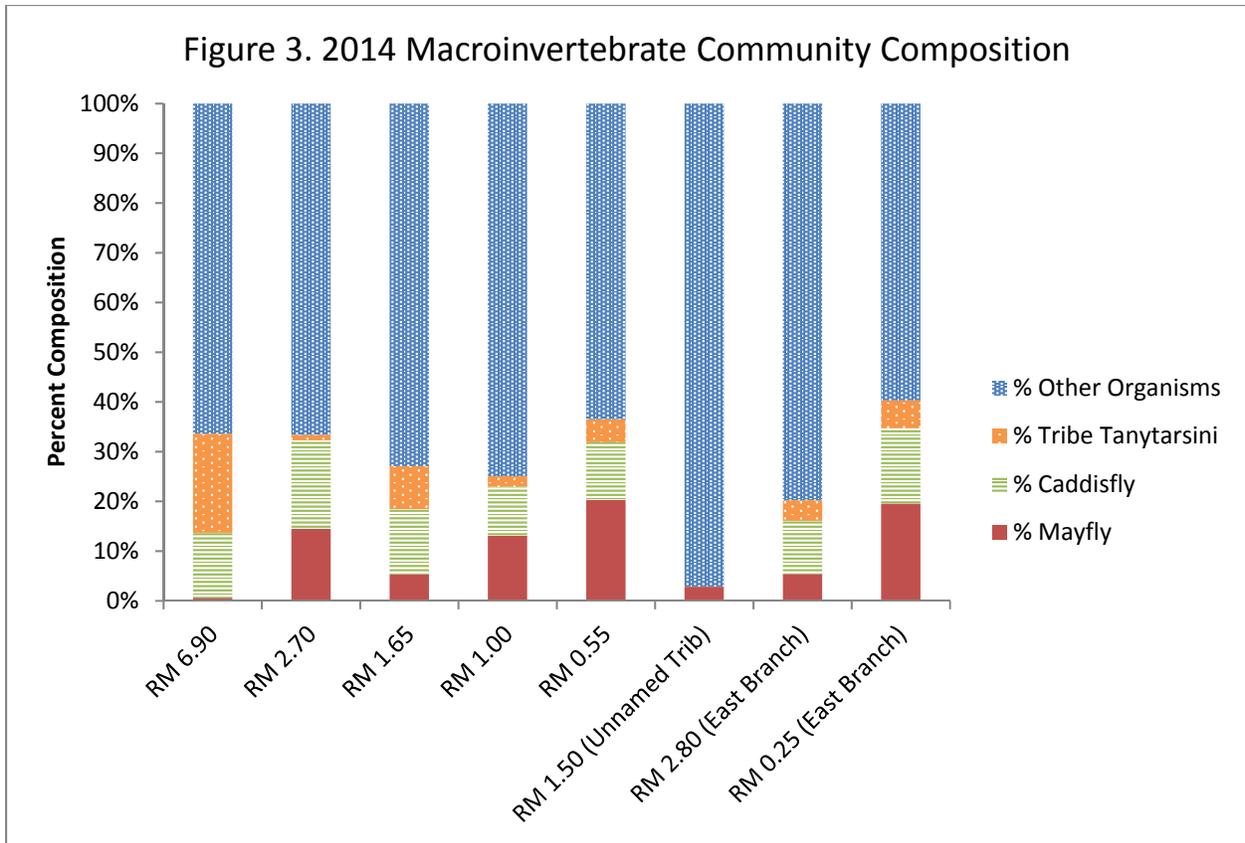
RM 0.25 (east branch) was in attainment of the ICI biocriterion in 2014 and 2013. Over 30% of the macroinvertebrate community consisted of mayflies and caddisflies (Figure 3). As previously mentioned, Ohio EPA monitored just downstream of RM 0.25 at RM 0.20 in 2008. The ICI score calculated by Ohio EPA was 24 and in non-

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attainment of the WWH ICI biocriterion. It appears that the biological monitoring should continue in order to evaluate the effectiveness of the restoration work.

RMs 0.55 and 6.90 both received ICI scores of 34, also meeting attainment of the ICI biocriterion. Of all of the 2014 sites in Euclid Creek, RM 0.55 had the highest number of EPT taxa collected during the qualitative assessment (Table 13). This site also had the highest number of caddisfly taxa collected on the HD, yielding a metric score of six. Similarly, RM 6.90 had a high number and percentage of caddisfly taxa collected, as well as a low percentage of tolerant organisms.

Table 13. 2014 Euclid Creek Macroinvertebrate Results					
River Mile	ICI Score	Narrative Rating	Total Quantitative Taxa	Total Qualitative Taxa	Total Qualitative EPT Taxa
RM 6.90	34	<i>Good</i>	27	17	3
RM 3.30		<i>Good-Marginally Good*</i>		25	5
RM 2.70	36	<i>Good</i>	26	25	5
RM 1.65	30	<i>Marginally Good</i>	31	28	7
RM 1.00	28	<i>Fair</i>	30	29	7
RM 0.55	34	<i>Good</i>	33	30	8
RM 0.40**	52	<i>Exceptional</i>	32	56	6
RM 1.50 (Unnamed Tributary)	18	<i>Fair</i>	17	17	3
RM 2.80 (East Branch)	28	<i>Fair</i>	19	20	5
RM 0.25 (East Branch)	36	<i>Good</i>	29	30	6
Bold indicates attainment of WWH biocriterion					
<i>Italics indicates non-significant departure of WWH biocriterion</i>					
*Narrative rating based on best professional judgment and habitat evaluation					
**LICI					
	HD not collected; qualitative assessment only				



The lowest ICI score in 2014 was at RM 1.50, an unnamed tributary to the main branch, which failed to meet the WWH ICI biocriterion. Over 97% of the community on the HD consisted of other dipterans and non-insects with only one mayfly and one caddisfly taxa collected, and three EPT taxa collected during the qualitative assessment (Figure 3). The macroinvertebrate community composition in 2013 was similar, indicating a lack of improvement from the previous year. This site is extensively channelized within a residential area, which may be having a negative effect on the macroinvertebrate community.

RM 1.00 also failed to meet attainment of the ICI biocriterion in 2014. Although there was an increased number and percentage of caddisfly taxa collected on the HD, nearly 75% of the HD consisted of other diptera and non-insects, and 39% of the HD was comprised of tolerant organisms. An HD was not retrieved at this site in 2013; however, there was an increase in the number of qualitative organisms collected and an increase in the total number of EPT taxa collected in 2014. The severe lack of margin habitat due to the concrete flume may be preventing a healthier community of macroinvertebrates.

At RM 0.40, the LICI score was calculated at 52 (*Exceptional*), meeting attainment of the LICI biocriterion. The HD at RM 0.40 was comprised of 67 taxa and had six metrics receive the highest score of six. The HD consisted of a low percentage of collector-gatherer taxa, which are taxa that tend to increase with increasing stream

degradation. Additionally, there was a high number and percentage of sensitive taxa, a high percentage of mayflies and caddisflies, and low percentage of other dipterans and non-insects. The qualitative assessment in 2014 at RM 0.40 included more intensive sampling of the adjacent wetland. Because the wetland was not qualitatively sampled in 2013, it is not possible to compare qualitative results from 2013 with 2014. Future qualitative sampling at RM 0.40 will include collection of macroinvertebrates from the wetland.

The ICI score at this site increased considerably from 2013, when it received a score of 36 (*Fair*). It is believed that the habitat restoration completed at this site may finally be showing a positive effect on the macroinvertebrate community. Further post-restoration monitoring should continue in order to track the trend of macroinvertebrate community health at the site.

The remainder of the Euclid Creek sites had a range of ICI scores (Table 14). RM 1.65 was in non-significant departure of the ICI biocriterion, receiving a score of 30 (*Marginally Good*). Although there was a high percentage of other dipteran and non-insects on the HD, the number of caddisflies and percentage of caddisflies metrics received the highest scores, which helped the site meet attainment. RM 2.80 (east branch) failed to meet attainment of the ICI biocriterion with a score of 28 (*Fair*). The composition of the HD was mainly other dipterans and non-insect organisms; however, there was a very low percentage of tolerant organisms. RM 3.30 was only qualitatively sampled and was assigned a narrative rating of *Good* to *Marginally Good* based on an overall assessment of the site and the macroinvertebrates collected during the qualitative sampling. Twenty-five taxa were collected, which was more than in 2013, with five EPT taxa and two moderately intolerant taxa.

RMs 2.70, 1.65 and 0.55 have been evaluated for macroinvertebrates since as early as 2002 to help determine the impact that NEORSD-owned CSOs may have on downstream biological communities. In 2014, RMs 0.55 and 2.70 were in attainment and RM 1.65 was in non-significant departure of the WWH ICI biocriterion; therefore, NEORSD-owned CSOs may not have had a negative impact on the health of the macroinvertebrate community in 2014. Historical data at RMs 0.55, 1.65 and 2.70 shows an overall increase in ICI scores since sampling began (Table 14). This is the second year that RM 0.55 was in attainment of the WWH ICI biocriterion since sampling began in 2002. Attainment at this site may be attributed to the habitat improvements that occurred downstream at RM 0.40 (Posius, 2013). Improvements at RM 0.40 may have allowed for better flow conditions at RM 0.55, unlike pre-restoration conditions, in which flow over the HD was highly variable.

Table 14. 2002– 2014 Euclid Creek ICI Scores			
	RM 2.70	RM 1.65	RM 0.55
2002	33	--	25
2003	--	--	26
2004	31	--	14
2005	--	--	16
2006	--	--	24
2007	36	26	22
2008	28	26	12
2009	36	38	24
2010	42	42	18
2011	--	36	24
2012	--	36	24
2013	42		34
2014	36	30	34
Bold indicates attainment of WWH biocriterion			
<i>Italics indicates non-significant departure of WWH biocriterion</i>			
--Macroinvertebrates not evaluated			
	HD not collected; qualitative assessment only		

Conclusions

The results of NEORSD’s water chemistry sampling, habitat assessments, and fish and benthic macroinvertebrate community surveys indicate that the Euclid Creek watershed may be impacted by a variety of aquatic habitat limitations and environmental stressors, as mentioned above. Water chemistry results at nearly all of the sites showed water quality exceedances for bacteria (Table 15). Potential sources of pollution include illicit discharges, CSO discharges and urban runoff.

Biological assessments that were conducted at all of the sites showed partial or non-attainment of WWH biological criteria. Although no definitive pattern was evident, it appears that site-specific habitat characteristics are the major limiting factor affecting the biological communities at all of the locations. Additionally, the East 185th Street dam, which is located upstream of RM 1.00, is inhibiting fish migration to the upper reaches of the watershed.

One of the objectives of this study was to determine the impact of NEORSD-owned CSOs on the downstream biological community at RM 0.55. Macroinvertebrate assessments at RM 0.55 showed that the benthic community was meeting the WWH ICI biocriterion for only the second time in nearly 13 years of sampling. Although this site lacked a functional riffle, the flow has improved greatly possibly due to the completion of

a restoration project located downstream at RM 0.40. Similarly, RM 2.70 and RM 1.65, both of which are located upstream of NEORSD-owned CSOs, were also in attainment of and in non-significant departure of, the WWH ICI biocriterion, respectively. Fish assessments at RMs 2.70 and 1.65 failed to meet the WWH IBI biocriteria, while RM 0.55 met attainment of the IBI biocriterion, but not the MIwb biocriterion.

A restoration project that was recently completed at RM 0.40 and was anticipated to increase the overall health of lower Euclid Creek failed to meet the LIBI biocriteria, but met the LICI biocriterion. With severe habitat limitations, such as heavy silt and a low abundance of aquatic vegetation, it is recommended that further fish assessments at RM 0.40 continue in order to monitor attainment status as the site has time to stabilize.

Restoration on the East Branch at RM 0.25 was completed in 2011, which consisted of a dam removal and installation of step-pools. This site was in partial attainment, meeting the WWH ICI biocriterion, but not the WWH IBI biocriterion. The establishment of a healthy WWH fish community at this site may be difficult due to the rock cross vanes that could be inhibiting upstream migration. Continued fish assessments are pertinent in order to monitor the fish population.

Overall, the water quality status of the Euclid Creek watershed is fair. Many of the sites may be negatively impacted by sources of pollution associated with bacteriological contamination from CSO discharges, improper connections, failing septic systems, and urban runoff. Moreover, documented storm sewer bacteriological contamination in Cleveland and Euclid remains an issue. Until these problems are remediated, bacteriological contamination remains an important concern by NEORSD for Euclid Creek.

Future monitoring of Euclid Creek will be vital as current and proposed NEORSD capital improvement projects are anticipated to control the number of CSO discharges to Euclid Creek. The Tunnel Dewatering Pump Station and Euclid Creek Tunnel projects began in December 2010 and the Euclid Creek Pump Station project began in the fall of 2014 with an anticipated 2015 completion for these projects. Further sampling post-construction will help determine the effectiveness of the projects and any improvements on the water quality, habitat and biological communities in Euclid Creek.

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Table 15. 2014 Euclid Creek Survey Results						
River Mile	Aquatic Life Use Attainment Status	Average IBI Score (Narrative Rating)	Average MIwb Score (Narrative Rating)	ICI Score (Narrative Rating)	QHEI Score (Narrative Rating)	Water Quality Exceedances
6.90	NON	22 <i>Poor</i>		34 <i>Good</i>	67.0 <i>Good</i>	<i>E. coli</i> , copper, zinc
3.30	PARTIAL***	32 <i>Fair</i>		-- <i>Good*</i>	64.5 <i>Good</i>	<i>E. coli</i>
2.70	NON	25 <i>Poor</i>	5.3 <i>Poor</i>	36 <i>Good</i>	63.0 <i>Good</i>	<i>E. coli</i>
1.65	NON	24 <i>Poor</i>	5.6 <i>Poor</i>	30 <i>Marginally Good</i>	74.0 <i>Good</i>	<i>E. coli</i>
1.00	NON	26 <i>Poor</i>	6.0 <i>Fair</i>	28 <i>Fair</i>	64.5 <i>Good</i>	<i>E. coli</i>
0.55	PARTIAL	36 <i>Marginally Good</i>	7.0 <i>Fair</i>	34 <i>Good</i>	59.75 <i>Good</i>	<i>E. coli</i>
0.40**	NON	24 <i>Poor</i>	7.1 <i>Fair</i>	52 <i>Exceptional</i>	47.0 <i>Fair</i>	<i>E. coli</i>
1.50 (Unnamed Tributary)	NON	20 <i>Poor</i>		18 <i>Fair</i>	59.5 <i>Good</i>	<i>E. coli</i>
2.80 (East Branch)	NON	22 <i>Poor</i>		28 <i>Fair</i>	69.25 <i>Good</i>	<i>E. coli</i>
0.25 (East Branch)	PARTIAL	32 <i>Fair</i>		36 <i>Good</i>	57.5 <i>Good</i>	<i>E. coli</i>
WWH biocriterion attainment: IBI score of 38; MIwb score of 7.9; ICI score of 34						
Non-significant departure: ≤4 IBI units; ≤0.5 MIwb units; ≤4 ICI units						
--HD not collected; qualitative assessment only						
*Narrative rating based on best professional judgment and habitat evaluation						
**Lacustrary scoring						
***Based on best professional judgment						

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